Hexavalent Chrome Free Coatings for Electronics Applications
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<u>Background</u>

The replacement of hexavalent chrome [Cr (IV)] in the processing of aluminum for high-reliability electronics applications in the aviation and aerospace sector remains a goal of great significance. Aluminum is the major structural manufacturing material used for avionics type packages both the aircraft (military and commercial) and space flight arena. The processing and maintenance of this material against degradation and corrosion is of prime importance to the electronics community in preserving our defense and space operations capabilities. This includes preserving the integrity of the structure and electronics components within, maintaining proper electrical conductivity, and minimizing impact on radio and electromagnetic interference qualities of the electronics package.

Key to the operability and preservation of aluminum substrates for electronic housings and avionics has been the use of chromated coatings, typically conversion coatings on interior spaces and coating systems (conversion coatings, primers) for exteriors and sometimes hard-chrome plating. Hard chrome plating on components is accomplished through an electrochemical process; the electrochemically adhered chrome provides barrier protection to the substrate by forming a dense self-healing oxide layer on the surface. Though some electronics applications may use hard-chrome plating, it is outside of the scope of this project. Conversely, with applied coatings, the high corrosion resistance offered by chromated films is attributed to the presence of both hexavalent and trivalent chromium in the coating. The trivalent chromium is present as an insoluble hydrated oxide, whereas the hexavalent chromium imparts a “self-healing” character to the coating during oxidative (corrosive) attack. Hexavalent chrome coatings also play a critical role in supporting and enhancing the adhesion of the primer coating to the substrate.

Occupational Safety and Health Administration (OSHA) studies have determined that hexavalent chromium poses significant medical risks to users. Hexavalent chromium is considered a potential lung carcinogen. Studies of workers in the chromate production, plating, and pigment industries consistently show increased rates of lung cancer. It has also been shown that direct eye contact with chromic acid or chromate dusts can cause permanent eye damage. Hexavalent chromium can irritate the nose, throat, and lungs and repeated or prolonged exposure can damage the mucous membranes of the nasal passages and result in ulcers. In severe cases, exposure causes perforation of the septum (the wall separating the nasal passages). It has also been proven that prolonged skin contact can result in dermatitis and skin ulcers. Some workers develop an allergic sensitization to chromium and kidney damage has been linked to high levels of dermal exposures.

While chromated systems (applied coatings and plated) have set the bar for treatment and protection of aluminum, it is now known that hexavalent chromium is carcinogenic and poses significant risk to human health. On February 28, 2006 OSHA lowered the 8 hour time-weighted average (TWA) Permissible Exposure Limit (PEL) for hexavalent chromium from 52 µg/m3 (micrograms per cubic meter of air) to 5 µg/m3. OSHA issued a deadline of May 31, 2010 for employers to comply with this PEL through the implementation of engineering controls. The final rule also includes provisions for employee protection such as preferred methods for controlling exposure, respiratory protection, protective work clothing and equipment, hygiene areas and practices, medical surveillance, hazard communication and record keeping. On April 8, 2009, the Under Secretary of Defense (Acquisition, Technology and Logistics) issued a memorandum establishing policy for the minimization of hexavalent chromium use throughout DoD. The result of this is that the DoD is proposing to amend the Defense Federal Acquisition Regulation Supplement (DFARS) to address requirements for minimizing the use of hexavalent chromium in defense weapon systems, subsystems, components, and other items. The proposed rule prohibits the delivery of items containing hexavalent chromium under DoD contracts unless an exception applies. This would apply to materials used in electronic systems as well, which to date has had little success in qualifying alternatives to hexavalent chrome for these types of applications.

In the interest of worker safety, as well as the cost and operational implications of new and pending environmental, safety and health regulations, both NASA and the US Department of Defense (DoD) continue to search for alternatives to hexavalent chrome in applied coatings and plating applications that meet performance requirements in corrosion protection, cost, operability, and health and safety; while underlining that performance must be equal to or greater than existing systems.

<u>Objective</u>

The objective of this project is to test promising conversion coatings / pretreatments to stakeholder specifications for electronics applications. Initial testing will focus on basic screening tests for corrosion, electrical resistance and adhesion. Further testing will include electromagnetic interference (EMI) and radio frequency interference (RFI) testing as well as rework and repair of conversion coatings / pretreatments that do not contain hexavalent chromium.

Period of Performance

- Formal project began March 2011

Stakeholders

National Aeronautics and Space Administration (Johnson Space Center (JSC), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), NASA's Crew Exploration Vehicle Program), United States Air Force, United States Army, United States Navy, Aerospace Industries Association, Arctic Slope Regional Corporation, ATK, Atlantic Inertial Systems, BAE Systems, Best Manufacturing Practices Center of Excellence, Boeing, Celestica, Defense Micro Electronics Agency, EADS, General Dynamics, Hamilton Sundstrand, Harris Corporation, Honeywell AERO, Lockheed Martin, Nihon Superior, Northrop Grumman, PWB Interconnect Solutions Inc., Raytheon. Rockwell Collins, Sandia National Laboratories, Spirit Aerospace, United Space Alliance, United Technologies Research Center

Benefits

- Meets environmental and safety regulatory requirements
- Meets DoD & EU Policy
- Reduces need to monitor for chromium exposure due to new regulations
- Decreased risk of environmental, worker and public exposure
- Reduced maintenance cost and government liability

Recent Progress

- Acquired test panels and materials for testing – February 2011
- Finalized Joint Test Plan – March 2011
- Labeled test panels – April 2011
- Added several new panels to test and etched – June 2011
- Identified several new coatings for inclusion in testing – June 2011

Document Status

- Joint Test Plan – Completed

Milestones

- Held kick-off meeting – April 2010
- Defined potential test specifications for initial and follow-on testing – April-July 2010
- Determined substrates for testing – July 2010
- Held face-to-face meeting at KSC – August 2010
- Began acquisition of coatings and test panels – August 2010
- Further developed JTP for initial testing – August 2010 – February 2011
- Received all test panels and materials for testing – February 2011
- Finalized JTP – March 2011
- Began test panel preparation (etching of panel numbers) – April 2011
- Interim Testing Report – June 2011

Future Goals

- Secure funding for testing at KSC – TBD
- Complete panel preparation – TBD
- Joint Test Report - DRAFT – October 2011
- Joint Test Report – FINAL – December 2011
- Phase II Recommendations Report – January 2012

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